LC
S

Volume 17 APRIL 13, 1942 Number 2

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

Library of Congress
APR 19 1942
Smithsonian Deposit

PROGRAMME OF THE

BALTIMORE MEETING

AT

THE JOHNS HOPKINS UNIVERSITY

May 1–2, 1942

THE LIBRARY OF CONGRESS
CENTRAL SERIAL RECORD
RECEIVED
MAY 6 - 1942
COPY

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

The American Physical Society

OFFICERS OF THE SOCIETY FOR 1942

President	P. W. Bridgman	Harvard University
Vice President	A. W. Hull	General Electric Company
Secretary	Karl K. Darrow	Bell Telephone Laboratories (Office at Columbia University)
Treasurer	George B. Pegram	Columbia University
Editor (on leave)	John T. Tate	University of Minnesota
Acting Editor	J. W. Buchta	University of Minnesota
Local Secretary for the Pacific Coast	R. T. Birge	University of California

COUNCIL

The President, Vice President, Secretary, Treasurer, Managing Editor, the three Past Presidents most recently retired from office, eight elected members and all Past Presidents first elected to the office of President prior to December 1932 constitute the Council which shall have general charge of the affairs of the Society.

Past Presidents: Henry Crew, W. F. Magie, Ernest Merritt, R. A. Millikan, J. S. Ames, Theodore Lyman, K. T. Compton, H. G. Gale, W. F. G. Swann, John Zeleny, George B. Pegram and G. W. Stewart.

Elected Members: E. U. Condon, A. J. Dempster, F. G. Brickwedde, H. D. Smyth, J. C. Boyce, A. E. Ruark, L. A. DuBridge and J. S. Foster.

BULLETIN

of the

AMERICAN PHYSICAL SOCIETY

Published seven times per year

Subscription price: $5.00 per year

Single copies: $1.00 each

The Bulletin of the American Physical Society is published seven times a year during the months of February, April, June (2 issues), November (2 issues), and December at Prince and Lemon Streets, Lancaster, Pa.

Address correspondence to Prince and Lemon Streets, Lancaster, Pa., or to Secretary Karl K. Darrow, Columbia University, New York, N. Y.

Entered at the post office at Lancaster, Pa., as second class matter.

Acceptance for mailing at a special rate of postage provided for in the Act of October 3, 1917, embodied in paragraph 4, Section 412, P. L. & R., authorized April 28, 1928.

APRIL 13, 1942 Vol. 17, No. 2

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

BALTIMORE MEETING, MAY 1–2, 1942

THE 248th regular meeting of the American Physical Society will be held at *Baltimore* on Friday and Saturday, May first and second, 1942. Many of our members will regret the departure from our long-established tradition that "Spring meeting" and "Washington meeting" are synonymous; but the reason is obvious and imperative, and it is expected that Baltimore will prove a very acceptable substitute. The Johns Hopkins University has volunteered to be our host, and all of the sessions will be held on its campus (entrance at North Charles and 34th Streets) in Remsen Hall. The first session will commence at ten o'clock on Friday morning.

Hotels. The Lord Baltimore Hotel (headquarters hotel for the meeting), the Southern Hotel, and the Emerson Hotel all offer rooms at $3.50 single, $5.50 double, and $6.00 double with twin beds. Dormitory accommodations are available at $2.00 per person at the two first-named hotels, for fifty and for a hundred persons, respectively. Members are urgently advised to make hotel reservations at their earliest convenience, since the congestion in Washington is tending to overflow into Baltimore at any moment; and members are reminded that it is the policy of hotels not to hold reservations into the evening hours unless specifically so requested (with indication of the presumptive hour of arrival of the guest).

Registration and information service will be established in Room 43 of Rowland Hall on the Johns Hopkins University campus.

Luncheon. The Local Committee informs us that several large apartment houses in the neighborhood of the University offer good luncheon service, and that a leaflet giving full details will be available at the registration desk.

Dinner. The dinner of the Society will be held on Friday evening at seven o'clock at the Lord Baltimore Hotel. The Duddell Medal of the Physical Society (of Great Britain) will be conferred upon Dr. W. D. Coolidge, and the presentation will be made by Viscount Halifax, British Ambassador to the United States. The price of the dinner will be $2.25 including tip.

Entertainment. Current conditions have deterred the Local Committee from arranging excursions and similar opportunities. However, Baltimore offers many features of interest to visitors. Information and suggestions for sightseeing and entertainment will be available at the registration desk, and at the hotels.

The **Council** will meet at 10:00 A.M. on Friday, May first, in Rowland Hall, Room 105.

The **summer meeting in the East** is to be held at Pennsylvania State College; it has been scheduled for June 25, 26, 27, but may not extend over three entire days. Arrangements are under way for a symposium on one or more topics of chemical physics, and for a joint symposium with the American Association of Physics Teachers on some topic of mutual interest.

APR 14 1942

The **summer meeting on the Pacific Coast** is to be held at Berkeley on July 11, 1942. The tradition of meeting with the Pacific Coast Division of the A. A. A. S. is thus also broken, for imperative reasons.

GENERAL RULES RELATING TO PAPERS

No paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for that meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of these abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

After the Berkeley Meeting subsequent meetings are planned as follows:

251. November, 1942. Chicago, Illinois.
252. December, 1942. Pacific Coast Meeting.
253. December, 1942. Annual Meeting. New York City.

KARL K. DARROW, *Secretary*
American Physical Society
Columbia University, New York, New York

April 13, 1942.

CALENDAR

Friday Morning, May 1

10:00 o'clock: Remsen Hall: Room 1—Session A. Papers 1–10. See pages 5–6.

10:00 o'clock: Rowland Hall: Room 105—Meeting of the Council.

Friday Afternoon, May 1

2:00 o'clock: Remsen Hall: Room 1—Session B. Papers 11–20. See pages 7–9.

Friday Evening, May 1

7:00 o'clock: Lord Baltimore Hotel: American Physical Society Dinner.

Saturday Morning, May 2

10:00 o'clock: Remsen Hall: Room 101—Session C. Papers 21–28. See pages 9–10.

10:00 o'clock: Remsen Hall: Room 1—Session D. Papers 29–39. See pages 11–13.

Saturday Afternoon, May 2

2:00 o'clock: Remsen Hall: Room 1—Session E. Papers 40–49. See pages 13–15.

PROGRAMME

Friday Morning at 10:00 o'clock

Remsen Hall—Room 1

Session A—Theoretical

1. Covariant Representation of Five-Dimensional Field Theories. Peter G. Bergmann, *Black Mountain College.*—To compare the five-dimensional and projective field theories proposed by Kaluza,[1] Veblen and Hoffmann,[2] Pauli,[3] and Einstein and collaborators[4] with each other, it is useful to develop a covariant formalism applicable to all of them. If one introduces in a five-dimensional Riemannian space with coordinates ξ^ρ a set of four parameters $x^\sigma(\xi^\rho)$, then it is possible to identify each curve x^σ=constant in the five-dimensional space with a "point" in a symbolic four-dimensional space. A complete tensor algebra and analysis can be constructed in this space of the x^σ. The four-dimensional metric is related to the five-dimensional metric, and the same is true of Christoffel symbols and curvature tensors. It turns out that, from this point of view, the theory of Kaluza and the projective theories are equivalent, while the theories of Einstein, Bargmann, and Bergmann are more general.

[1] Kaluza, Sitz. Preuss. Akad. Wiss. (1921), p. 966.
[2] Veblen, *Projektive Relativitätstheorie* (Berlin, Springer, 1933).
[3] Pauli, Ann. d. Physik **18**, 305 (1933); **18**, 337 (1933).
[4] A. Einstein, Ann. Math. **39**, 683 (1938); *Th. v. Kármán Anniversary Volume* (Pasadena, 1941), p. 212.

2. On the Quantization Problem in Hydrodynamics. L. Tisza, *Massachusetts Institute of Technology.*—The problem of liquid helium has been recently attacked by Landau[1] from an entirely new viewpoint. While there is hardly any doubt that the problem has to be treated on the lines advanced by Landau, his development of *quantum hydrodynamics* does not seem quite satisfactory. It is suggested to start rather from classical hydrodynamics and restrict the modes of internal motion of the perfect liquid by quantum conditions. This leads (1) to longitudinal phonons, (2) to vortex rings with quantized angular momentum $\frac{1}{2}M\Gamma = J\hbar$, where M is the mass of the vortex ring, $\Gamma = \oint \mathbf{v} d\mathbf{s}$ the circulation, both constant according to classical theorems; J is a quantum number taking discrete, but not necessarily integer values. M varies for the different vortex rings from a minimum value compatible with the corpuscular structure of the liquid to a maximum value determined by the geometry of the container of the liquid. It will be shown that the thermo- and hydrodynamical properties of this system correspond to those of liquid helium. The results agree only partly with those of Landau. The reasons for the discrepancies and the experiments supporting the present theory will be discussed.

[1] L. Landau, Phys. Rev. **60**, 356 (1941), J. of Phys. **5**, 71 (1941).

3. Magnetic Force of Charge on Charge. F. W. Warburton. *Illinois Institute of Technology.*—The Riemann force of charge on charge satisfies not only the unipolar induction experiment with the rotating solenoid but also that for the rotating magnet. The high velocity term in the centripetal acceleration of the electron averaged over a circular orbit, balances the average value of another term in velocity of the electron. When the magnet rotates, the Coriolis acceleration term for an electron in an orbit, expressed in terms of the vector potential and integrated for the magnet, balances the relative motional term. The correction term in mutual force corresponding to relativistic increase in mass, although vanishing for a closed circuit, looms large for a massive body near a conductor whether or not the body is magnetic or rotating.

4. A New Method for Deriving Poynting and Other Valid Energy Flow Vectors. J. Slepian, *Westinghouse Research Laboratories.*—A thin shell space enclosing a portion of an electromagnetic field is imagined suddenly created, and charges, electric and magnetic dipoles are introduced along the inner and outer shell surfaces and moved about so as to keep the field within the shell space itself, zero, and the field enclosed by the shell, the same, for sometime, as it would have been if the shell had not been created. The work done upon the moving charges and dipoles is defined to be the flux of electric energy out from the enclosed electromagnetic field. This work can be assigned to the elements of the enclosing surface in various ways—one yielding the Poynting vector, and the others yielding other valid energy flow vectors having the same divergence as the Poynting vector. If a spatially distributed stored energy density is also assigned to these charges and dipoles, then valid energy flow vectors are obtained which differ from the Poynting vector even in their divergence. These valid energy flow vectors assign an energy density in space differing from but equally valid with usual spatial energy density postulates.

5. Theoretical Half-Lives of RaE and P^{32}. E. Greuling, *Indiana University.*—It has been shown[1] that the asymmetric energy distribution of RaE electrons can be accurately predicted by the "second forbidden" tensor or polar vector interactions if the transition corresponds to no parity change with a spin change, $\Delta J = 2 \rightarrow 0$. The correct energy distribution *and the observed half-life* can be obtained concurrently if the magnitudes of the nuclear matrix elements, constructed from certain irreducible tensors, are estimated by a simple averaging process.

Agreement with experiments is given by the tensor interaction with the reasonable assumptions: (1) The velocity of nuclear particles, $v \approx 1/6C$, and (2) The Fermi constant, $g \approx 4.6 \times 10^{-12}$. The observed energy distribution of P^{32} electrons cannot be accurately predicted in any "forbidden" approximation. The ratio of the nuclear matrix elements assumed[1] in order to fit Lawson's data at two points, corresponds to an unreasonably small nuclear velocity, $v \approx 0.03C$, and yields a half-life ~ 100 times too large in the "second forbidden" approximation. For $v \geq 1/10C$ the spectrum predicted differs very little from that given by the "first forbidden" tensor interaction with $\Delta J = 2 \rightarrow 0$. This transition, $P^{32}_{odd} \rightarrow S^{32}_{even}$, yields the correct half-life when $g \approx 2.1 \times 10^{-12}$ is assumed. In view of the fact that the energy distribution favors only slightly the "second forbidden" approximation, the evidence of the half-life indicates that P^{32} is probably "first forbidden" according to Gamow-Teller selection rules.

[1] E. J. Konopinski and G. E. Uhlenbeck, Phys. Rev. **60**, 308 (1941).

6. Electric Quadrupole Moments of Light and Heavy Nuclei. S. B. WELLES, *Yale University*.—From the results of Feenberg and Wigner[1] for the wave function and term character of the ground state of light nuclei in the Hartree Model, and from the results of Rose and Bethe[2] for the corresponding nuclear spins, the electric quadrupole moments of these nuclei have been computed. In units of 10^{-26} cm^2, they are $Li^{6,7,8}$ 0, -2.7, 1.4; $Be^{7,8,9}$ -3.6, 0, 2.1; $B^{9,10,11,12}$ -0.6, 0, 0.7, -3.8; $C^{11,12,13}$ -2.4, 0, 0; $N^{13,14,15}$ 0, 0, 0; and $O^{15,16}$ 0, 0. A theoretical investigation of the quadrupole moments of heavy nuclei as a function of nuclear spin reveals certain regularities if it is assumed that the asymmetrical charge distribution is due to only one proton. No restrictions as to the type of coupling are included.

[1] E. Feenberg and E. Wigner, Phys. Rev. **51**, 95 (1937).
[2] M. E. Rose and H. A. Bethe, Phys. Rev. **51**, 205 (1937).

7. On The Magnetic Moments of H^3 and He^3. R. G. SACHS AND JULIAN SCHWINGER, *Purdue University*.—The magnetic moments of the light nuclei constitute a source of information concerning the extent to which spin conservation laws are relaxed in many-body systems. The sum of the moments of two nuclei which can be obtained from each other by an interchange of neutrons and protons has a particularly simple interpretation since it depends only on the amount of admixture of the possible LS states. Of this class of nuclei, H^3 and He^3 are of particular interest since the magnetic moments of both can presumably be measured. The theoretical value of the sum of their moments is

$$\mu_{H^3} + \mu_{He^3} = \mu_n + \mu_p - \tfrac{3}{8}(\mu_n + \mu_p - \tfrac{1}{2})(3^4D + 2^2P - {}^4P),$$

where the state symbols indicate the probability that the system be found in the corresponding state. It is likely that the ground states of these nuclei are predominately $^2S + {}^4D$ and thus, if $^4D = 5$ percent, $\mu_{H^3} + \mu_{He^3} = 0.841$ nuclear magneton, which is to be contrasted with the deuteron moment (0.857), the expected theoretical value if $L-S$ coupling holds rigorously. The moment of the individual nuclei depends on the detailed structure of the ^4D function but if a particularly simple form[1] is assumed one finds

$$\mu_{H^3} = \mu_p - \tfrac{3}{8}(2\mu_p + \mu_n - \tfrac{1}{2})^4D,$$

whence $\mu_{H^3} = 2.68$ and $\mu_{He^3} = -1.84$.

[1] E. Gerjuoy and J. Schwinger, Phys. Rev. **61**, 138 (1942).

8. On the Algebraic Theory of Higher Spins. M. DRESDEN, *University of Michigan*.—It has been shown that particles of spin 0, $\frac{1}{2}$, 1, can be described by a set of linear equations of the Dirac type. An attempt to a possible extension of this type of equation has been made. The method starts, using a method of factorization due to Rainich,[1] by obtaining all possible commutation relations which will insure that the second-order wave equations are satisfied by each wave function as a consequence of the first-order equations. This is done by writing down the conditions on the coefficients for the splitting of a quadratic form into 2 linear forms, then the condition for the splitting of a quadratic form in a linear and a quadratic form and so on. The general relations are of the form $\Sigma_P \beta n_1 \beta n_2 \cdots \beta n_s = \Sigma_P \delta n_1 n_2 \beta n_3 \cdots \beta n_s$. They allow many special solutions among others the Dirac and Duffin relations. The next complicated will be presented and its physical contents discussed.

[1] G. Y. Rainich, Bull. Am. Math. Soc. **48**, No. 1, p. 41.

9. The Magnetic Current in Gases. FELIX EHRENHAFT.—In analogy with the definition of the electric ion a magnetic ion is a body which moves in a *homogeneous* magnetic field in the direction of the lines of force, reverses its direction of motion with the reversal of this field, etc. A magnetic current consequently is the movement of magnetic ions in the homogeneous magnetic field. To this extension of physical conceptions the author has been forced since he observed movements in homogeneous magnetic fields which hitherto were unknown. In an homogeneous magnetic field *some* particles of various finest metal powders, especially such of ferromagnetic elements, move from one homogeneous magnetrode (the plate of a magnetic condenser) to the opposite one, while the others remain at rest. A particle suspended in gas irradiated by light moves in the homogeneous magnetic field in the lines of force and reverses its direction with the reversal of the field. The determination of the charge on these ions and the change of charge on them are discussed. The author has made these experiments in cooperation with L. Banet. He restricts himself to the reports of the investigations on gases while the latter will report about the movements in liquids, and give some references.

10. The Magnetic Current in Liquids. LEO BANET. (*Introduced by Felix Ehrenhaft.*)—The above-given definitions of magnetic ions and magnetic currents can also be

applied to movements in liquid mediums. The following observations have been made: Colloidal particles of nickel[1] are deposited equally on two homogeneous (gold-plated) magnetrodes.—Single particles of these colloids can be observed moving toward the magnetrodes by means of a microscopic arrangement. Some particles of finest metal powders move in the homogeneous magnetic field toward the magnetrodes in various liquids. These movements cease instantly if the magnetic field is shut off and start just the same way.

[1] F. Ehrenhaft, Anzeiger d. kais. Akad. d. Wiss. Wien **24** (July 10, 1902); Phil. Mag. **11**, 1931 (1940); Ann. d. Physique **13**, 151 (1940); J. Frank. Inst. **230** 381 (1940); Phil. Sci. **8**, No. 3 (1941); Science **94**, 232 (1941); J. Frank. Inst. **235** (March, 1942); F. Ehrenhaft and L. Banet, Phil. Sci. **8**, No. 3 (1941); J. C. Maxwell, *Treatise*, art. 377–379 (Oxford, 1902).

FRIDAY AFTERNOON AT 2:00 O'CLOCK

Remsen Hall—Room 1

Session B—Experimental Nuclear Physics; Cosmic Rays

11. The Characteristic Radiations of CO^{60}. MARTIN E. NELSON, M. L. POOL, AND J. D. KURBATOV, *Ohio State University.*—The 10.7-minute Co^{60} was produced by a $Co(d, p)$ reaction in an intensity several thousand times that obtained from $Co(n, \gamma)$ and $Ni(n, p)$ reactions. Ionization chamber measurements indicated that approximately one gamma-ray was emitted for each beta-ray. The lead absorption coefficient for the gamma-ray activity was 0.58 cm^{-1}, corresponding to an energy of 1.5 ± 0.2 Mev. The beta-rays were measured with a magnetic beta-ray spectrometer and were found to be continuous. Allowing for the slight tail due to gamma-ray recoils the endpoint was measured at 1.35 ± 0.1 Mev. This is probably an allowed transition. The 5.3-year Co^{60} was produced by a $Co(d, p)$ reaction. Chemical separations removed the long life impurities. Absorption measurements, in agreement with those previously reported,[1,2] indicated the presence of a 1.7 ± 0.2 Mev gamma-ray and a 220 ± 20 Kev beta-ray. However, no higher energy electrons were observed. From these data it seems evident that an isomeric transition between the 11-minute and 5.3-year periods does not occur but that the activities decay independently. An energy level diagram summarizing the data will be shown.

[1] J. R. Risser, Phys. Rev. **52**, 768 (1937).
[2] J. J. Livingood and G. T. Seaborg Phys. Rev. **53**, 847 (1938).

12. *K*-Electron Capture in Radioactive Argon A^{37}. PAUL K. WEIMER, J. D. KURBATOV, AND M. L. POOL, *Ohio State University.*—Further measurements upon the radioactive argon A^{37} previously reported[1] give a half-life of 34.1 ± 0.2 days. Preliminary observations made by introducing the gas directly into a cloud chamber indicate the isotope decays primarily by *K*-electron capture. This has been confirmed by critical absorption measurements using the gases H_2S and CCl_2F_2 as absorbers. The radioactive gas was enclosed in an 18 cc container having a 0.25-mil aluminum window. This container was mounted at the top of a specially constructed ionization chamber filled with the absorbing gas. A movable screen was used to vary the thickness of this gas between the aluminum window and the effective part of the ionization chamber. The ratio of the maximum ionization current obtained with this arrangement to that obtained when the same quantity of radioactive gas was admitted directly into the ionization chamber was observed. By comparison of this ratio for argon with a similar ratio for a radioactive gas emitting a much harder radiation, a direct calculation of the internal conversion coefficient of the x-rays has been made.

[1] P. K. Weimer, J. D. Kurbatov, and M. L. Pool, Phys. Rev. **60**, 469 (1941).

13. Photoneutrons Produced in Beryllium by the γ-Rays of Radio-Antimony (60 d). G. STANLEY KLAIBER AND GERTRUD SCHARFF-GOLDHABER, *University of Illinois.*—Previous work[1] has shown, that the energy of neutrons generated in Be by the hard γ-rays of RdY (100 d) is equal to that of RdTh+D neutrons (220 Kev). This result was obtained by counting the proton recoils produced by the photoneutrons in a hydrogen filled ionization chamber as a function of the discriminator voltage. From the photoneutron energy the energy of the γ-ray can be calculated (1.87 Mev). Now this work has been extended to the γ-ray of Sb^{124} (60 d). A sample of a few millicuries of Sb^{124} was kindly produced for us by Dr. Kamen by bombarding antimony with deuterons in the Berkeley 60-inch cyclotron. Proton recoils due to photoneutrons from Sb^{124}+Be were observed and their distribution in energy measured. The arrangement was calibrated by means of a pulse generator and a value of 115 ± 20 Kev for the Sb^{124}+Be neutrons was obtained. This leads to an energy of 1.75 Mev for the γ-ray emitted by Sb^{124}. Mitchell *et al.*[2] obtained for this γ-ray a value of 1.82 Mev from Compton electrons.

[1] G. Scharff-Goldhaber, Phys. Rev. **59**, 937(A) (1941).
[2] A. C. G. Mitchell, L. M. Langer, and P. W. McDaniel, Phys. Rev. **57**, 1107 (1940).

14. Collision Cross Sections of C and H for 25 Mev Neutrons. R. SHERR, *Harvard University.*—Lithium bombarded with 10.2-Mev D^+ ions is known to yield neutrons with a maximum energy of 25.4 Mev. The reaction $C^{12}(n, 2n)C^{11}$ provides an energy-sensitive detector with

calculated threshold at 20.6 Mev. By placing graphite at different angles with respect to the direction of the deuteron beam, it was found that the 20.5 min. C^{11} activity decreased rapidly with falling neutron-energy and was gone at 21.5 Mev. For the scattering experiment, the effective area of the Li target was 2.0×0.3 cm²; the target detector separation was 22 cm; the graphite detector was 4.5 cm long with a cross section of 1.9×1.6 cm² facing the target. The scatterers of graphite and paraffin were rectangular blocks with cross section 2.54×2.54 cm² placed midway between target and detector. Tests indicated negligible effect due to neutrons scattered by the cyclotron and water tanks. The collision cross sections did not vary for transmissions from 40 percent to 70 percent and were found to be 0.39×10^{-24} cm² for $n-p$ and 1.05×10^{-24} cm² for $n-C$, to an estimated accuracy of 10 percent. These values will be somewhat increased by appropriate corrections for geometry.

15. The Origin of Statistical Fluctuations in Proportional Geiger Counters. W. F. G. SWANN, *Bartol Research Foundation of the Franklin Institute.*—In a proportional Geiger counter 25 cm long filled with argon at 40-cm pressure, something like 700 ions would be produced in the whole path length. If all of these were produced as single pairs by the original cosmic rays, there would be no basis for appreciable fluctuation. However, the theory of ionization results in a very appreciable fraction of the measured ionization coming from acts in which the ion originally ejected has enough energy to produce many ions. The number of these acts is sufficiently small to be affected by statistical fluctuations, but the ions associated with them are sufficiently many to make those fluctuations affect a large portion of the total ionization. The paper will give the details concerning these matters.

16. Pulse Size as a Function of Pressure in Geiger-Mueller Counters. CARLTON W. MILLER AND C. G. MONTGOMERY, *Yale University.*—A vacuum tube circuit was used to measure the size of the pulses from a Geiger-Mueller counter which was over-shooting. This was done in the pressure range from two centimeters to thirty centimeters of mercury for the gas mixtures 90 percent argon, 10 percent hydrogen; 90 percent neon, 10 percent hydrogen; 90 percent helium, 10 percent hydrogen; and for 100 percent hydrogen—all of tank purity. Since the pulses were observed to have distribution in size, sufficient measurements were taken to give information concerning the variation of this distribution with pressure and voltage. The 100 percent hydrogen gave the greatest pulse size observed (900 volt pulses at pressure equal to 30 cm Hg and at an over-voltage of 500 volts), with the mixtures giving pulses of lesser size in the same order as they are listed above. In each case, as the pressure was lowered, the pulses were larger at the lower over-voltages. The width of the plateau decreased as the pressure was lowered, making extensive measurements at low pressures impossible. Graphs of the data are presented, showing pulse size as a function of pressure and voltage, and the variation of the size-distribution. The accuracy of the measurements is discussed.

17. Production of Penetrating Particles in the Cosmic Radiation. VICTOR H. REGENER, *University of Chicago.*—The production of penetrating particles in 5 and 10 cm of lead, iron, carbon, aluminum, and paraffin was investigated at Climax, Colorado (3500 m) in January, 1942. The altitude dependence of the production in lead was measured between Climax and Chicago. The apparatus consisted of several counter trays between layers of absorbing material and yielded simultaneously cross section and multiplicity for the production, as well as the absorption of the produced particles. The production of penetrating particles by a non-ionizing component of the cosmic radiation here considered is of the multiple type and differs from the production of soft mesotrons by photons. The material-dependence of the production rate shows per g/cm² of producing material an inverse trend with the atomic number; this inverse z dependence and the high rate of production make it necessary to introduce appreciable corrections for lifetime measurements of the mesotron where an absorber of dense material is used to compensate for the absorption in air between stations at different altitude. The absorption coefficient in lead of the produced particles depends on the atomic number of the material where the production took place.

18. Further Measurements of the Mesotron Lifetime. BRUNO ROSSI AND KENNETH GREISEN, *Cornell University,* JOYCE C. STEARNS, DAROL K. FROMAN, *University of Denver,* AND PHILLIP G. KOONTZ, *Colorado State College.*—New experiments have been performed in order to test the theoretical relation between momentum and average range before decay of mesotrons and to determine more accurately the value of the proper lifetime. Differential absorption measurements of mesotrons have been carried out with an anti-coincidence method, at Denver (1616 m above sea level) and at Echo Lake (3240 m above sea level). The experimental results yield the differential momentum spectrum of mesotrons at Echo Lake from 3×10^{8} to 1.2×10^{9} ev/c, and enable one to calculate the probability of survival between Echo Lake and Denver for two fairly monoenergetic mesotron groups. The average effective momenta of these groups are $p_a=5.15\times10^{8}$ and $p_b=9.72\times10^{8}$ ev/c, respectively. The corresponding average ranges before decay, as deduced from the probabilities of survival, are $L_a=(4.26\pm0.46)\times10^{5}$ cm and $L_b=(8.5\pm1.9)\times10^{5}$ cm. Thus, within the experimental errors, the average ranges are in the same proportion as the momenta, in agreement with the prediction based on the relativistic transformation of time intervals. From the above measurements and with a mesotron mass of 10^{8} ev/c², one obtains the value $\tau_0=2.8\times10^{-6}$ sec. for the proper lifetime of mesotrons.

19. The Energy Distribution in Showers at Low Energies. J. A. RICHARDS, JR. AND L. W. NORDHEIM, *Duke University.*—A numerical method for the calculation of the energy distribution in showers is developed. It consists of

a series of successive approximations which permit one to continue the known asymptotic functions at high energies towards lower energies. In this way the track length distributions for electrons and photons in high energy showers have been calculated for both air and lead down to an energy of about 4 Mev. Close approximations to the true probabilities for the radiative effects have been used at all energies and Compton effect and collision secondaries have been fully taken into account. The electron distribution increases logarithmically at very low energies and can be extrapolated to obtain the total track length of particles of all energies. The value thus obtained agrees very closely with the value following from energy considerations.

20. Theory of the Lateral Spread of Cosmic-Ray Showers. JANE ROBERG, *Duke University.* (*Introduced by L. W. Nordheim.*)—Following the procedure of Nordheim,[1] a systematic method is developed to calculate the mean square angular and lateral spreads of shower particles of all energies to any desired accuracy. An analytical solution, which takes the effect of ionization into account, is found for high energies, while for lower energies a method of successive approximations can be carried through numerically. These more precise calculations confirm previous estimates and show that Auger's observations on large air showers can be accounted for by the theory.

[1] Nordheim, Phys. Rev. **59**, 929A (1941).

FRIDAY EVENING AT 7:00 O'CLOCK

Lord Baltimore Hotel

Dinner of the American Physical Society

Presentation, for the Physical Society (of Great Britain) by Viscount Halifax, of the Duddell Medal to Dr. W. D. Coolidge.

SATURDAY MORNING AT 10:00 O'CLOCK

Remsen Hall—Room 101

Session C—Spectra

21. Replica Gratings for Large Schmidt Telescopes. R. W. WOOD, *The Johns Hopkins University.*—Grating replicas have been mounted in mosaic form on a glass disk 18 inches in diameter for the 18-inch Schmidt telescope at Mt. Palomar, California. The elementary replicas measure 4×6 inches, and for the blue and violet region over 95 percent of the light is in the first-order spectrum and less than 1 percent in the central image. There are only 800 lines to the inch, as very short spectra are required for spectral classification of very faint stars in rich fields to prevent overlapping. A similar 18-inch grating with 1500 lines to the inch has been made which enables one to distinguish between novae and planetary nebulae, the latter giving a nitrogen band very near the bright hydrogen line. This grating gives the highest intensity in the red region. The objective prism is unable to resolve the two lines. Lantern slides, experiments, and exhibits.

22. Hyperfine Structure of the Forbidden Line λ2967.52 of Hg I. S. MROZOWSKI, *University of Chicago.*—The structure of the forbidden mercury line λ2967.52 ($6^3P_0-6^1D_2$) was investigated in the third order of each of two 30-foot Chicago gratings. The current of a powerful watercooled mercury arc was correspondingly adjusted so as to produce a relative weakening by reabsorption (end-on observation) of the very strong neighboring line λ2967.28 ($6^3P_0-6^3D_1$). Four sharp components were observed in the forbidden line: 0 (10), +0.553 (5), +0.828 (4), and +1.048 cm^{-1} (<1); the intensities given in parenthesis are values estimated on a scale of 10. The structure observed agrees very closely with that predicted for this line by Goudsmit and Bacher[1] several years ago. Hence the first component is emitted by Hg^{199} and the remaining three by Hg^{201}. The forbidden line has an electric dipole character; the emission is caused by hyperfine structure perturbations occurring only in energy levels of the odd isotopes of mercury.

[1] S. Goudsmit and R. F. Bacher, Phys. Rev. **43**, 894 (1933).

23. Fine structure and Series Extension in the Alkali Metal Atomic Spectra. H. R. KRATZ, *University of Wisconsin and Princeton University.*—The tube already

described[1] for the production of a long optical path in a short space has been improved by supporting the optical parts on an I beam, with the aid of sylphon tubes, for stability with changing temperature, and by the installation of facilities for uniform heating to any temperature up to 500°C, controllable to about 0.1°C. Twelve members of the principal series of potassium have been resolved into doublets, and 75 members have been measured. Similar work is progressing upon rubidium and caesium.

[1] H. R. Kratz and J. E. Mack, Phys. Rev. **57**, 1059A (1940).

24. Bands in the Vapors of the Alkali Metal Atoms, in a Long Absorption Path. J. E. MACK AND H. R. KRATZ, *University of Wisconsin and Princeton University.*—In connection with the work described in the previous paper, with optical paths of tens of meters, many bands have appeared, including an especially simple weak absorption band in the neighborhood of the red potassium doublet, possibly attributable to NaK.

25. Raman Spectrum of Hexachloroethane. FORREST F. CLEVELAND, DWIGHT T. HAMILTON, AND M. J. MURRAY, *Illinois Institute of Technology.*—Beginning a study of some ethane type molecules, the Raman spectrum of Cl_3C-CCl_3 dissolved in carbon tetrachloride and chloroform has been obtained. The Raman data for hexachloroethane in the order *displacement* (*intensity*) *depolarization factor* are: 162(½)0.7; ±223(6)0.8; ±340(5)0.8; ±431(8)0.3; 859(5)0.9, and 975(2)0.4. (± means observed as both Stokes and anti-Stokes lines.) Previous data obtained for hexachloroethane in the order {*number of times line was observed*} *mean displacement* (*mean intensity*) *depolarization data* are: {3} 144(1)r; {9} 220(4)v; {12} 340(4)v; {12} 432(7)r; {1} 673(0); {9} 858(3)v; {3} 978(1)−. (r, v=right and left circularly polarized.) Since the Cl atoms are large enough to exert considerable forces upon each other, it seems reasonable to suppose that rotation of one CCl_3 group with respect to the other about the C−C bond is restricted by a high potential barrier and that the equilibrium configuration is one in which the CCl_3 groups have their symmetry planes displaced by $\pi/3$. This configuration D_{3d} should yield, in agreement with the above observations, three polarized and three depolarized Raman lines, as contrasted with three polarized and six depolarized Raman lines for either the D_{3h} or the D_{3h}' configurations.

26. Analysis of the Near Ultraviolet Absorption Spectrum of Phenol. MAURICE B. HALL,* *Duke University.*—Near ultraviolet absorption spectrograms of phenol, obtained with a Hilger E-1 quartz spectrograph, were studied. To a good approximation the spectrum was found to conform to the requirements of the C_{2v} symmetry class, being very similar to the spectra of the monohalogenated benzenes. The 0, 0 band ($A_1 \rightarrow B_1$ transition) occurs at 36351 cm^{-1}. Progressions with spacings of 782 cm^{-1} and 935 cm^{-1}, and intercombinations of the two, were found arising from totally symmetric vibrations. The difference 478 cm^{-1}, occurring alone and in combination with some totally symmetric levels, was assigned to a β_1 vibration. This vibration is considered to correspond to the ϵ^+_g vibration in benzene whose excitation is responsible for the near ultraviolet benzene absorption. Bands displaced from the main bands by about 60 cm^{-1} and 218 cm^{-1} towards longer wave-lengths are explained as $v-v$ transitions. A small influence of the hydrogen atom of the OH group is suggested in some minor features.

* Now at National Institute of Health, Bethesda, Maryland.

27. On the Theory of the "Color" of Unsaturated Aliphatic Chains. U. FANO, *Carnegie Institution of Washington.*—The spectral absorption bands of aliphatic molecular groups having increasing numbers of conjugated double bonds (up to 11) are progressively shifted towards red. The shift is, however, much slower than theoretically expected according to Bloch's approximation. Since this approximation is particularly inaccurate in one-dimensional systems, other qualitative considerations are presented here. In Heitler-London's approximation, the fundamental state is entirely non-ionic, but the lowest optically excited state includes only ionic configurations. The smallest optically absorbed frequency is then primarily determined by the energy difference between non-ionic and ionic configurations, which is a zero-order effect, rather than by the strength or number of bonds. (The matrix elements interconnecting ionic and non-ionic configurations are assumed here to be small, but when the chain is sufficiently long their large number upsets Heitler-London's approximation.) Thus no major shift of the absorption bands would be expected for chains of moderate length, if the energy difference between ionic and non-ionic configurations (neglected in Bloch's approximation) were the dominant factor. As things are, this factor is probably strong enough to oppose appreciably the shift towards red, thus explaining the experimental findings.

28. Influence of l-Quantum Number on the Structure of X-Ray Absorption Edges. R. SMOLUCHOWSKI, *General Electric Company.*—The transition probability of an electron in absorption of an x-ray quantum depends upon the wave function of the lower state. Most of the studies of the fine structure of x-ray absorption edges consider only the K edge and do not reveal this dependence. Besides, for solids, almost no quantitative theoretical considerations are possible. In case of molecular gases, however, Kronig's theory can be extended to other edges and quantitative predictions made. Experimental study of the fine structure of the L_{I}, L_{II}, and L_{III} absorption edges of mercury in gaseous $HgCl_2$ were made in order to study the influence of the orbital quantum number on the structure. The results indicate that the L_{I} edge has a structure different from that of the L_{II} and L_{III} edges at least within the observed range of energies. The L_{II} and L_{III} edges have identical structures as expected. Theoretical results for L_{I} are in good agreement with experiment. A quantitative comparison of the structure of the other two edges with the extended theory has not yet been carried out.

SATURDAY MORNING AT 10:00 O'CLOCK

Remsen Hall—Room 1

Session D—Mostly Electrical

29. Electron Polarization. C. G. SHULL,* *New York University.*—In treating the scattering of electrons by atomic nuclei, Mott[1] has shown that the interaction of the electron's magnetic moment with the scattering nucleus is such as to cause an intensity asymmetry upon the double scattering of a beam of electrons. Experimental observation of this effect is a crucial test of the validity of the Dirac equations for electrons. This experiment has been repeated using a 400 kev beam of electrons scattered by thin gold foils and counted by Geiger-Müller counters. After eliminating spurious asymmetries, a polarization asymmetry of 8 percent was found, which became 1 percent in the opposite direction when an aluminum foil was inserted for one of the gold foils. Reducing the atomic number of the scattering centers in this way should theoretically reduce the polarization asymmetry to a much smaller value. A distinction has been determined between polarization asymmetries as obtained in a "reflection" experiment (in which only electrons scattered through the "reflecting" sides of the foils are studied) and in a transmission experiment (in which only electrons scattered through the transmitting sides are studied). Experimental data will be shown and analyzed.

* Now with The Texas Company, Beacon, New York.
[1] N. F. Mott, Proc. Roy. Soc. **135**, 429 (1932).

30. Abnormal Scattering of Electrons. PAUL E. SHEARIN, *University of North Carolina.*—Skobelzyn[1] reports that, in at least ten percent of the cases, the angle of scattering of a primary electron, in an electron-electron collision, is much greater than that to be expected from energy and momentum considerations. For expected angles of scattering of about 4°, he reports angles as great as 40°. A stereoscopic visual examination of the 180 side-branches of energy superior to 20 Kev occurring on 343 meters of primary electron track of energy between 1.3 and 2.6 Mev, studied in a recent investigation by Pardue[2] and the author, disclosed no marked abnormal scattering. Ninety-one of these events were suitable for accurate angular measurements, and were utilized in the present work. The angle of deflection of the primary in a plane approximately parallel to the primary track was measured. In only one case was the measured angle appreciably greater than the calculated angle, and this discrepancy could be accounted for by a nuclear collision near the electron-electron collision.

[1] Skobelzyn, Comptes rendus **21**, 431 (1938).
[2] Shearin and Pardue, Proc. Am. Phil. Soc. **85**, 243 (1942).

31. Secondary Emission of Electrons from Molybdenum Plates Coated with Beryllium and Treated with HCl. PAUL L. COPELAND AND WILLIAM R. KENNEDY, *Illinois Institute of Technology.*—Molybdenum plates used in these experiments were placed in vacuum and outgassed. Beryllium was then evaporated to form thick films upon them. The plates, after being removed from the vacuum system, were washed first with concentrated hydrochloric acid and then with distilled water to remove all visible traces of the beryllium film. After such plates had been placed in experimental tubes for the measurement of secondary emission and outgassed at a bright red heat, they showed relatively high secondary emission over a wide range of primary energies. A maximum of something more than three secondaries per primary appeared at a primary energy of about 500 electron volts.

32. Proton Production by Electron Collisions in Molecular Hydrogen. HERBERT F. NEWHALL, *Cornell University.*—The collision processes leading to the production of protons by single electron collisions with molecular hydrogen were investigated, using a mass spectrometer for the analysis. The electron beam was coaxial with a cylindrical conductor, and the field due to the electron space charge was used as an energy selector for the ions. The ions measured were those moving initially at right angles to the beam. The "fast" protons (ions having several electron volts of energy) found by Bleakney[1] were observed, and a rough measurement of the cross section for their production was made. No evidence was found for the slow protons observed by Bleakney. It is believed that these were formed by secondary collision processes. Using the theory developed by Smith,[2] it is possible to compute roughly the energy distributions of the ions. The distributions are in accord with the potential energy curves of the hydrogen molecule.

[1] W. Bleakney, Phys. Rev. **35**, 1180 (1930).
[2] L. P. Smith and P. L. Hartman, J. App. Phys. **11**, 220 (1940).

33. The Polarization Parameters of Several Solid Dielectrics and Their Changes with Temperature and Composition. ROBERT F. FIELD, *General Radio Company.*—According to K. S. and R. H. Cole the changes in dielectric constant and loss factor with frequency for a single polarization in any dielectric are such that a plot of loss factor against dielectric constant is a circular arc with its center depressed below the dielectric constant axis. Three parameters are sufficient for specifying the polarization: the change in dielectric constant from zero to infinite frequency, the relaxation frequency, and the storage coefficient which is related to the depression angle. Important derived quantities are the zero frequency and infinite frequency dielectric constants and the maximum loss factor. Values of these six parameters have been calculated for several dielectrics from published data which cover a wide temperature range. The temperature coefficients of zero frequency dielectric constant, change in

dielectric constant, and storage coefficient are negative. Relaxation frequency is an increasing exponential function of temperature.

34. The Effect of High Electrostatic Fields upon the Vaporization and Resistance of Molybdenum Filaments. WALTER P. REID, *University of Pittsburgh.*—In 1921 Worthing observed decreases in the vaporization rates and resistances of W filaments upon application of sufficiently high electrostatic fields directed radially outward. The filaments returned to normal upon removing the fields. Later Gaylord Estabrook investigated the phenomena in greater detail using Mo filaments. Vaporization rates as small as 1 percent of that without a field were obtained. He found increases in resistance however upon application of the fields. Lloyd Jones working more recently with a very good vacuum did not observe either effect. A careful study of the results obtained by Estabrook reveals that the phenomena mentioned, as well as other factors involved, can be explained by postulating that an adsorbed layer of oxygen forms on the filament surface upon application of a field, and leaves upon its withdrawal. Equations based upon such an assumption are found to fit Estabrook's observed variation of vaporization rate with field strength. The sudden change in resistance is attributed to a temperature change resulting primarily from a small change in emissivity.

35. The Effect of High Electrostatic Fields on the Conductivity of Tungsten. PETER L. VISSAT, *University of Pittsburgh.*—A grounded tungsten wire (0.0078-mm diameter) was mounted coaxially to a cylinder made negative relative to the wire and a difference of potential was applied between cylinder and wire. The procedure consisted of measuring the resistance of a tungsten wire first without an electric field and then with a field. With a vacuum of about 10^{-6} mm Hg and with fields of about 10^{6} volts/cm, measurements showed that: (1) An increase in resistance always resulted with the application of the field. (2) The change was different for different temperatures of the filament and for different vacuum conditions. (3) No measurable change occurred unless the field exceeded a certain value. (4) A small leakage or ionization current was associated with the changes in resistance. The observed changes might have been caused by: (1) leakage current, (2) ionization current, (3) radial stress in the wire resulting from the high field, or (4) other reasons. Calculations showed that reasons (1) and (3) produce changes much smaller than those observed and that the results are explainable wholly by reason (2) if it is assumed that most of the ionization occurs near the surface of the wire.

36. The Mechanism of the Electric Spark. JOHN ZELENY, *Yale University.*—A criticism is given of Meek's derivation of a formula for the radial field arising from the positive ions in an electron avalanche. The importance ascribed by Loeb and Meek to this radial field in the development of a spark discharge is questioned because values of sparking potentials in equal agreement with experiment can be obtained on the simple assumption that a spark will pass when the number of electrons liberated in an avalanche is 10^{9}. This assumption also leads to sparking potentials in a gas at different pressures which are in agreement with Paschen's law. The significance of the necessity of the production of a large number of electrons is ascribed to the photo-ionization that accompanies ionization by electron impact. This photo-ionization must reach a certain magnitude before it can definitely give rise to a conducting path between the two electrodes. The probability that such a path will be produced by a given amount of photo-ionization may well depend on the path length, and this may account for the fact that the values of sparking potentials computed by the formula on the assumption of a constant number of electrons fall more and more below the observed values as the distance between the electrodes is increased.

37. A Mass Spectrometer of Wide Adaptability. N. D. COGGESHALL, *University of Illinois.*—The simultaneous fulfillment of the conditions for: high sensitivity; high dispersion; comparative freedom from space charge effects; simplicity of operation; and inexpensive construction have been attained in an instrument for the measurement of relative abundances. Important features of the design are (1) the elimination of non-uniform and distorted magnetic fields in the source region as previously used in the 60° type of spectrometer, and (2) simplicity of construction and alignment. The ions are created in a magnetic field free region in which the electron beam moves perpendicular rather than parallel to the first slit. They are then accelerated towards this slit by an electrical field which remains fixed throughout a run. The final energy of the ions after passing through a second accelerating field is approximately 1000 volts. The ion source is constructed as a unit in such a way that an accurate alignment of the slits is readily accomplished and different source arrangements may be used. After leaving the source, the ions are deflected through a mean angle of $\pi/3$ radians by a uniform sector shaped magnetic field into a Faraday cup. The corresponding ion beam currents are measured directly by means of the usual electrometer tube arrangement.

38. Mobility of He^{+} in He. ROLAND MEYEROTT, *Yale University.* (*Introduced by H. Margenau.*)—Tyndall and Powell have concluded from their measurements[1] that the mobility of He^{+} in He is 21.4, a value which is in flagrant disagreement with that calculated by Massey and Mohr (12).[2] An improved calculation of the force law does not remove this discrepancy, while on the other hand the experimental value has been confirmed. An examination of the earlier work of Tyndall and Powell[3] reveals the value 13 for the mobility. The two determinations differ only in the nature of the ion sources used. It is suggested, from consideration of these ion sources, that the value 21.4 refers not to the mobility of He^{+} in He but to that of the molecule-ion He_2^{+} in atomic helium, and that the value 13 be taken as the mobility of He^{+} in He. Evidence for these conclusions will be presented.

[1] Tyndall and Powell, Proc. Roy. Soc. **134**, 125 (1931).
[2] Massey and Mohr, Proc. Roy. Soc. **144**, 188 (1934).
[3] Tyndall and Powell, Proc. Roy. Soc. **129**, 162 (1930).

39. Electronically Controlled Variable Capacity. L. GRANT HECTOR, GORDON GUERNSEY AND CHESTER MARCINKOWSKI, *University of Buffalo.*—Variable capacity condensers are ordinarily obtained by the simple expedient of arranging one set of plates of a multiplate condenser to be moved either by hand or by a motor. The effective amount of capacitative reactance in a circuit may also be varied by placing a fixed condenser in the circuit with a variable series resistance included. If the variable series resistance consists of the plate circuit of a thermionic tube, variable capacitative reactance may be obtained without the use of mechanical moving parts. Both the type and the extent, as well as the rate of the variations can be controlled by the signal imposed on the grid of the tube. One application of the device is to produce warble tones for acoustical measurements. An obvious current application of this method for producing warble tones of various types is in combination with sirens as air raid warning signals.

SATURDAY AFTERNOON AT 2:00 O'CLOCK

Remsen Hall—Room 1

Session E—Mainly Solid State

40. A Magnetic Study of the Superconducting Transitions of Hydrides and Nitrides of Columbium and Tantalum. F. HUBBARD HORN, W. F. BRUCKSCH, JR., W. T. ZIEGLER AND D. H. ANDREWS, *The Johns Hopkins University.*—Measurements of magnetic induction were carried out in a duplex cryostat similar in design to the one reported by Simon in which liquid helium was produced by the expansion method in an upper vessel and the cooling effect transferred by refluxing to the lower vessel in which the samples were placed. Results may be summarized as follows where the composition is given in atom percent, the temperature in °K refers to the midpoint of the transition and the figures in parentheses give the approximate width of the transition: Columbium, pure metal, 8.98°K (0.4°); 5.06 percent H, 7.83° (2.1°); 9.89 percent H, 7.38° (3.2°); 32.76 percent H, 7.28° (3.2°). Tantalum, pure metal, 4.08°K (0.2°); 3.97 percent H, 3.62° (0.8°); 7.54 percent H, 3.26° (1.2°); 11.93 percent H, 2.81° (1.8°). At the lowest temperature obtained, 2°K, tantalum nitride failed to become superconducting. In columbium nitride (CbN) superconductivity first appeared at about 14.5°K and the substance passed through a transition 1.3° in width as the temperature was lowered. A direct electrical measurement of the resistance on a sample of compressed powder showed a drop in resistance from about 10 ohms in the normal state to 0.4 ohm when superconducting.

41. On the Adiabatic Demagnetization of Iron Alum. J. A. SAUER,* *Harvard University.*—Experiments performed by Casimir and De Haas[1] on the adiabatic demagnetization of iron alum from high initial fields have determined the relationship between the magnetic moment and the field strength. The proper qualitative form of this relationship was derived from theoretical considerations by the same authors but only for the case of low values of the initial magnetizing field. For high values no theoretical solution was available. This is now obtained by using a method of attack originally developed by Van Vleck but extending it to include the effect of the crystalline field that, together with the magnetic dipole-dipole interaction, hinders the free orientation of the paramagnetic ions. The theoretical expression for the variation of the adiabatic magnetic moment with the magnetic field strength is found to compare favorably, quantitatively as well as qualitatively, with that determined by experiment. It is also shown that if the true thermodynamic temperature be determined by the method of De Haas and Wiersma—T proportional to H—the error involved is negligible over a suitable temperature range.

* Now at Mellon Institute, University of Pittsburgh.
[1] H. B. G. Casimir and W. J. De Haas, Physica **7** (1940).

42. Crystal Planes Developed by d.c. Heating of Tantalum. D. B. LANGMUIR, *RCA Research Laboratories, Inc.** —The "etching" of metallic surfaces by action of steady voltage gradients[1] has been studied. Tantalum strips 0.001" thick and 1–5 mm wide often recrystallize with grain diameters over 1 mm when heated to about 2500°K. Heating to about 2100°K in vacuum with d.c. for several hours causes surfaces to become deeply ridged. Spacing between adjacent ridges is of order 0.01 mm. Opposite sides of the same crystal grains usually show radically different surface structures. A.c. heating develops no structure, surfaces remaining mirror smooth. Negligible evaporation occurs. Twelve crystal grains have been studied by both x-ray and optical observations. Laue back reflection patterns showed the orientation of the body-centered cubic axes. Using a simple optical goniometer, reflections from the macroscopic "etched" surfaces have been found to be sharp in some cases to 2° and in most to better than 5°. The combined observations give the Miller indices of the macroscopic surfaces developed by the d.c. heating. The prominent optical reflections (2 or 3 from an average crystal) come from surfaces coinciding mostly within 5° with low index atomic planes. (110), (211), and

(100) surfaces have been found. Which particular set of surfaces develops depends upon the orientation of the crystal axes and upon the polarity of the current flow. Were optical measurements alone made, the false conclusion could be drawn that the crystal had a polar axis.

* Now employed by the Office of Scientific Research and Development, Washington, D. C.
[1] R. P. Johnson, Phys. Rev. **54**, 459 (1938).

43. The Crystal Structure of Tetraphenyl Arsonium Tri-iodide. ROSE C. L. MOONEY, *Newcomb College, Tulane University.*—As part of a study of the effect of cation size upon the structure and properties of tri-iodide compounds in the solid state, the crystal structure of tetra-phenyl arsonium tri-iodide, $(C_6H_5)_4AsI_3$, has been determined by means of x-rays. The cation tetrahedron, previously measured in the iodide, has an edge of almost eight angstroms. Unlike the better known tri-iodides, the tetraphenyl arsonium salt is very stable and extremely insoluble. The diffraction data was obtained from very small single crystals by the equi-inclination Weissenberg technique. The structure was determined directly from x-ray data by Fourier methods. The crystal is monoclinic, and has the symmetry of $P2/n(C_{2h}^4)$. There are two molecules in a cell of dimensions, $a=15.31$A, $b=7.63$A, $c=10.61$A; angle $\beta=93.4°$. The density, from x-ray measurements, is 2.04 g/cc. The arsenics and one pair of iodines are, respectively, in rotation axes and symmetry centers. The remaining parameters, forty in number, have also been accurately determined, so that there is excellent agreement between observed and calculated structure amplitudes. The tetraphenyl arsonium ions are packed between layers of tri-iodide ions, with carbon-iodine coordination distances of 4.15A.

44. Dispersion of Sound at High Frequencies in Cylindrical Rods. GEORGE E. HUDSON, *Brown University.* (*Introduced by R. B. Lindsay.*)—The theory of elastic vibrations in solid circular cylindrical rods of homogeneous isotropic materials is redeveloped from the general equations of elasticity with the following general results: (1) for any mode of vibration the ratio of the velocity of any elastic wave travelling along the rod to the velocity c_0 of shear waves is the same for any two rods whose Poisson ratios are equal and whose ratios of circumference to shear wave-length are equal, (2) if the velocity of propagation for any particular mode remains less than c_0 as the frequency or radius is increased indefinitely, this velocity approaches that of Rayleigh surface-waves, (3) a considerable simplification is introduced into the method of computing dispersion curves for any mode. This investigation generalizes and extends the work of Bancroft,[1] on elongational waves, and, further, a table of dispersion curves for the flexural mode of vibration is computed. The dispersion curves for magnesium are compared with the experimental results of Shear and Focke.[2] Excellent agreement between theory and experiment is obtained for the first elongational and flexural branches.

[1] Bancroft, Phys. Rev. **59**, 588–593 (1941).
[2] Shear and Focke, Phys. Rev. **57**, 532–537 (1940).

45. An Experimental Study of the Vibrations of Incomplete "Free-free" Circular Rings. F. P. BUNDY AND CLYDE W. BANKES, *Ohio University.*—The rings used in this investigation had air gaps of nearly 4° between the free ends. The first five modes of vibration in the plane of the ring and the first four modes of vibration transverse to the plane of the ring were successfully produced. In each case the frequency and the "form" of the vibration were determined as accurately as possible. It was found that the frequency of vibration in the plane of the ring is given accurately by the expression,

$$f_n=(K_n/D^2)(EI/m)^{\frac{1}{2}},$$

where n is the mode of vibration, D the mean diameter of the ring, EI the bending stiffness in the plane of the ring, m the mass per unit length, and K_n a constant which depends upon n. The frequencies for vibrations transverse to the plane of the ring are given by a similar expression in which the "constant" K depends upon n and the ratio of bending stiffness to torsional stiffness.

46. Use of the Pierce Interferometer for Measuring the Absorption of Sound in Gases.* HOWARD C. HARDY, *University of New Hampshire.*—An empirical equation has been used by Pielemeier to measure the absorption of sound in gases at high frequencies. It gives the energy absorption coefficient per wave-length, μ, as

$$\mu=\frac{2.303}{N_B-N_A}\log_{10}\frac{\Delta I_A}{\Delta I_B},$$

where

ΔI_A, ΔI_B = differences between the plate current at resonance and anti-resonance, the reflector being at positions A, B.
N_B-N_A = the number of whole wave-lengths between A and B.

This equation is here derived from theoretical considerations of the principles of the Pierce interferometer and the quartz oscillator and is found to be an excellent approximation when certain conditions as to reflector position and sound energy are fulfilled. The criteria for accurate measurement at high frequency of absorption coefficients are set up and experimental verification is shown. A more complete explanation of the effect of sound resonance on the quartz oscillator is given also.

* This research was carried out at the Pennsylvania State College, State College, Pennsylvania.

47. The Translational Dispersion of Sound in Gases. H. PRIMAKOFF, *Queens College.*—The translational dispersion of sound in gases is discussed from the standpoint of kinetic theory. The distribution function for molecular velocities in a gas carrying a sound wave is used to determine the space and time dependence of the gas pressure, density, and mean molecular velocity. Thus, an explicit relation is derived for the variation of the sound velocity V, with frequency; in monatomic gases this relation is: $V=V_0(1-5.4l^2/\lambda^2)$, where l is the molecular mean free path and λ is the wave-length. The possibility of experi-

mental observation of translational dispersion is briefly discussed.

48. The Coefficient of Thermal Diffusion of Argon and Its Variation with Temperature. L. G. STIER, *University of Minnesota.*—Nier has measured the coefficients of thermal diffusion of methane[1] and neon[2] and in both cases observed a definite temperature dependence. Using the 9,5 Lennard-Jones[3] model of intermolecular forces with appropriate modifications, Jones obtained quantitative agreement with Nier's experimental results. The same theory also predicts that R_T is negative for temperatures less than $1.54T_c$, where R_T is the ratio of α to the value computed for hard spheres and T_c is the critical temperature. For argon the coefficient would be negative in the range 90° to 195°K. The coefficient of thermal diffusion of argon has been measured over seven different temperature intervals from 90°K to 833°K. In all cases α was positive. The results show that within experimental error α varies linearly with $\ln T$ if T is the "average" temperature over the range as calculated from Sutherland's model.[4] The R_T's fall between those of neon[2] and methane[1] for corresponding temperature ranges and agree with those computed from measurements of binary mixtures of the rare gases.[5]

[1] A. O. Nier, Phys. Rev. **56**, 1009 (1939).
[2] A. O. Nier, Phys. Rev. **57**, 338 (1940).
[3] R. C. Jones, Phys. Rev. **59**, 1019 (1941).
[4] Harrison Brown, Phys. Rev. **58**, 661L (1940).
[5] B. E. Atkins, R. E. Bastick, and T. L. Ibbs, Proc. Roy. Soc. **A172**, 142 (1939).

49. Effect of Double Layer on the Forces Between Neutral Molecules and Metal Surfaces. W. G. POLLARD, *University of Tennessee.*—Consideration is given to the question whether the existence of a double layer, such as that considered by Smoluchowski[1] in connection with the electronic work function, will profoundly modify the van der Waals force[2] between a metal surface and a neutral atom. It is found that the "spreading" effect[1] increases the coefficient of the van der Waals force without changing its (asymptotic) dependence on distance of separation; the relative change in the energy is given by $\Delta W/W \approx 20(p/e)r_s$, p being dipole moment per unit area of the surface layer, r_s the radius of the s sphere. For sodium this change amounts to only about 7 percent, but for tungsten it may increase the energy by as much as 50 percent. The difference between the various faces is small. An investigation of the "smoothing" effect shows it to produce a dependence of forces on distance differing from the R^{-4}-law; in fact the energy decreases exponentially. While it modifies strongly the forces near the surface and is therefore important in a complete consideration of the adsorption problem, it does not change the asymptotic form of the interaction.

[1] R. Smoluchowski, Phys. Rev. **60**, 661 (1941).
[2] H. Margenau and W. G. Pollard, Phys. Rev. **60**, 128 (1941).

Author Index to Abstracts of Contributed Papers Presented at the Baltimore Meeting

Andrews, D. H.—see Horn, F. Hubbard

Banet, Leo—No. 10
Bankes, Clyde W.—see Bundy, F. P.
Bergmann, Peter G.—No. 1
Brucksch, W. F., Jr.—see Horn, F. Hubbard
Bundy, F. P. and Clyde W. Bankes—No. 45

Cleveland, Forrest F., Dwight T. Hamilton, and M. J. Murray—No. 25
Coggeshall, N. D.—No. 37
Copeland, Paul L. and William R. Kennedy—No. 31

Dresden, M.—No. 8

Ehrenhaft, Felix—No. 9

Fano, U.—No. 27
Field, Robert F.—No. 33
Froman, Darol K.—see Rossi, Bruno

Greisen, Kenneth—see Rossi, Bruno
Greuling, E.—No. 5
Guernsey, Gordon—see Hector, L. Grant

Hall, Maurice B.—No. 26
Hamilton, Dwight T.—see Cleveland, Forrest F.
Hardy, Howard C.—No. 46
Hector, L. Grant, Gordon Guernsey, and Chester Marcinkowski—No. 39
Horn, F. Hubbard, W. F. Brucksch, Jr., W. T. Ziegler, and D. H. Andrews—No. 40
Hudson, George E.—No. 44

Kennedy, William R.—see Copeland, Paul L.
Klaiber, Stanley and Gertrud Scharff-Goldhaber—No. 13
Koontz, Phillip G.—see Rossi, Bruno
Kratz, H. R.—No. 23
—— see Mack, J. E.
Kurbatov, J. D.—see Nelson, Martin E.
—— see Weimer, Paul K.

Langmuir, D. B.—No. 42

Mack, J. E. and H. R. Kratz—No. 24
Marcinkowski, Chester—see Hector, L. Grant
Meyerott, Roland—No. 38
Miller, Carlton W. and C. G. Montgomery—No. 16
Montgomery, C. G.—see Miller, Carlton W.
Mooney, Rose C. L.—No. 43
Mrozowski, S.—No. 22
Murray, M. J.—see Cleveland, Forrest F.

Nelson, Martin E., M. L. Pool, and J. D. Kurbatov—No. 11
Newhall, Herbert F.—No. 32
Nordheim, L. W.—see Richards, J. A., Jr.

Pollard, W. G.—No. 49
Pool, M. L.—see Nelson, Martin E.
—— see Weimer, Paul K.
Primakoff, H.—No. 47

Regener, Victor H.—No. 17
Reid, Walter P.—No. 34
Richards, J. A., Jr. and L. W. Nordheim—No. 19
Roberg, Jane—No. 20
Rossi, Bruno, Kenneth Greisen, Joyce C. Stearns, Darol K. Froman, and Phillip G. Koontz—No. 18

Sachs, R. G. and Julian Schwinger—No. 7
Sauer, J. A.—No. 41
Scharff-Goldhaber, Gertrud—see Klaiber, Stanley
Schwinger, Julian—see Sachs, R. G.
Shearin, Paul E.—No. 30
Sherr, R.—No. 14
Shull, C. G.—No. 29
Slepian, J.—No. 4
Smoluchowski, R.—No. 28
Stearns, Joyce C.—see Rossi, Bruno
Stier, L. G.—No. 48
Swann, W. F. G.—No. 15

Tisza, L.—No. 2

Vissat, Peter L.—No. 35

Warburton, F. W.—No. 3
Weimer, Paul K., J. D. Kurbatov, and M. L. Pool—No. 12
Welles, S. B.—No. 6
Wood, R. W.—No. 21

Zeleny, John—No. 36
Ziegler, W. T.—see Horn, F. Hubbard